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ABSTRACT

This paper presents an interpretation of the term "concept," as the term is used in Ausubelian learning theory to define the unit of organization in cognitive structure. Several facets of a concept are described, a model of a concept is presented, and the model is then discussed and criticized as a heuristic device to aid educators in understanding certain aspects of teaching and learning. The latter portion of the paper discusses the types of expertise considered necessary for facilitating meaningful learning, culminating in a simplified model of curriculum and instruction. (CS)

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On Concepts and Their Acquisition

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SE 033 248

Paper presented at the Third International Congress on Education held at the Queen Elizabeth Hotel, in Montreal, Canada, June 1-4, 1980.

Introduction - The significance of concepts

So as to enable discourse on concept acquisition one needs to first of all clarify what a concept is. This is no simple task for the concept of a "concept" has been debated by philosophers, linguists, psychologists and other scientists from various disciplines without providing an adequate model. In fact, whether concepts exist at all may be a debatable issue. For some psychologists--those of a behavioristic persuasion--it makes little sense to speak of mental entities, therefore, concepts if they exist can be viewed as groups of stimuli resembling one another by virtue of the response patterns that they elicit. Cognitive psychologists who wish to understand the higher mental functions--thinking, problem solving, intelligence, and so on--view concepts as mental entities that are acquired through learning and experience, and modified over time.

If the above issues are debatable, the question of whether the clarification of the concept of a "concept" is important, is not debatable. Concepts are the tools of human thought and understanding (Toulmin 1972). Concepts are also the "basic units" of learning. That is, by acquiring concepts through a process of meaningful learning, human beings become capable of the sophisticated thought and understanding characteristic of the human species (Pines 1977, 1978). Our perception of reality is, so to speak, filtered through a myriad of conceptual-propositional structures that have been learned through experience via a process of meaningful learning (Ausubel 1968, Ausubel, Novak, and Hanesian 1978). Furthermore, our ability to learn meaningfully in the future is facilitated and limited by what has been learned

meaningfully in the past.

From a cognitive point of view we can describe an individual's idiosyncratic knowledge as a cognitive structure comprised of concepts related to one another. Such a cognitive structure can be depicted as a semantic network in which the nodes are concepts and the lines signify propositional relationships. An example of a semantic network that may represent a portion of a cognitive structure appears in figure 1.

Place figure 1 approximately here

In this example the structure is hierarchical. The more abstract concepts appear higher up in the network and the more concrete examples appear at the bottom. Obviously the network is highly simplified for purposes of illustration, nevertheless, it contains the essence of this author's grasp of the concept of "development."

If concepts are important, if when they are organized in cognitive structure they facilitate learning and understanding, then it is of utmost importance for the educator to understand their nature. It is the purpose of this paper to provide the basics for such understanding. Several essential facets of a concept will first be described. Then a model of a concept will be presented. Like all other models this model has limitations. However, it can be used as a heuristic device to grasp some essential features of concepts. Moreover, as will be shown, this model can be used by educators in understanding certain aspects of teaching and learning. Finally, the model will be criticized so that its inadequacies can be fully comprehended by those who wish to use the model.

Some essential features of concepts

There are three essential features of a concept upon which I wish to elaborate. Without any one of these aspects a concept ceases to exist. What may be interesting in discussing these features is that often the relationship between a feature and the concept of "concept" seems arbitrary, yet without that feature there is no concept.

The most central feature of a concept, one upon which I will later elaborate in my model, is that of a regularity. A concept has as its core a regularity in objects, events, or other concepts. In a sense understanding a concept means knowing a rule for categorizing, a recognition of which members belong to the conceptual category and which don't, and the relationships and differences between members of one category or conceptual class and those of another.

The second feature of a concept is its label. This name that is provided for a concept enables both communication amongst human beings and the manipulation of concepts in an individual cognitive structure. In the mature adult very little thought can be accomplished independent of the labels that consititute the bulk of our language. The interesting aspect of this feature of a concept is that it is largely arbitrary. Although some linguistic structuralists would disagree (Pettit 1975), I believe that segments of the language can be arbitrarily changed without seriously violating the conceptual structures that they denote. For example, that regularity that we call "chair" would not suffer by substituting the nonsense syllable "zug." Essentially, zug would henceforth come to denote the same meaning as chair had in the past. The fact that different languages exist in which identical concepts are expressed serves as a clear example for the arbitrariness of many labels.

Thus (1a) chaise and stuhl have the same meaning as chair in French and German, respectively. This is not to say that languages are completely translatable, they are not. Some languages make conceptual distinctions that others fail to and therefore we can indeed postulate together with Whorf (1956) that language, to some degree, structures perception and cognition. Surely language does place a limitation on cognition.

The third facet of a concept is the concept user. The world does not come prepackaged in conceptual categories, rather concepts are a culture's way of slicing up reality so as to enable communication and an optimal functioning in the world. An individual is born into a culture and acquires that culture's language, which in turn, will be transmitted to future generations. Over a long period of time the language will slowly become modified and change. Should such a culture, however, be annihilated the language and the concepts of that culture would cease to exist. Or more generally if the human species ceased to exist (a situation which regrettable is not improbable) then there would be no concepts. This may at first blush seem unacceptable because we have come to view concepts as existing "out there" in the real world. Being a realist I do not consider the world as a figment of human imagination; I do recognize certain realities that impose restrictions upon human conceptualization of reality, but at the same time I recognize concepts as a human creation which exists in human minds and in the communication between human beings.

The trifaceted structure of conceptualization is depicted in figure 2.

Place figure 2 approximately here

In the next section I will elaborate on the core of conceptualization - regularities. However, educators should be aware of the profoundly important role that labels and human concept users play as components of conceptualization. I will not belabor these facets further in my discussions although we will be talking about concept acquisition which entails human learners in a later portion of this paper.

The Conic Structure of a Concept - A Model

The model that I wish to adumbrate makes use of the geometrical structure of a cone. This rigid structure has the features necessary to clarify certain aspects of a concept that I wish to stress: It is a circumscribed area at one end which funnels into a point at the other end. The rigidity of this structure, will place artificial limitations that distort the nature of a concept; it will make concepts seem totally inflexible when in fact they are very flexible. I will elaborate upon the shortcomings of the model in the next section. The model does, however, serve as a powerful heuristic device for understanding some crucial elements of a concept.

Figure 3 depicts the conic model of a concept.

Place figure 3 approximately here

The bottom end of the cone is a circumscribed circle labeled "extension." This circle signifies the extension of the concept, the members of the category which the concept denotes. Thus if we again refer to the concept of a "chair" all those entities that could be categorized as chairs would fall into the circle--they would be part of the extension. Those entities that fall outside of the extension would not be members of the class or category that we call chairs.

The top end of the cone is a point labeled intension . This point is, as it were, the extraction of the meaning of the concept, its essence. Again, if we use the concept of chair as an example, the intension would be the "sameness" about all those entities in the extension that we call chairs. Why do we categorize a certain entity as being a chair, what is the rule that we use to classify members and non members, or what is the definition or meaning of "chair?" This regularity, rule, or definition is the intension of the concept.

When we move from the extension of a concept to its intension we are involved in the task of conceptualizing. We are finding the regularity, the rule or sameness about a category. If the processes were solely of this type we would conclude that conceptualization is an inductive process of looking at individual instances in order to derive a general definition. I will argue that learning a concept is rarely of this nature although many books and articles in developmental psychology would have us believe that this is the way concepts are acquired.

When we move from the intension of a concept to its extension we are applying the concept. That is, once you understand the rule or regularity you can go about categorizing members of the extension and distinguishing them from non-members of the extension. As opposed to the inductive direction from extension to intension, the application which goes in the direction from intension to extension is clearly deductive. The logical way to understand concept acquisition would be to view concept acquisition as an inductive process whereby rules and regularities are learned through examples and then once the concept

has been acquired it can be applied deductively by following the consequences of applying the rules. In fact this is not the case! It is the limitation and rigidity of this model that encourages this misconception.

To start with, concepts are not clearly delineated categories nor are they captured in simple rules or definitions. (I will elaborate upon this inadequency of the model in the next section.) It follows then that concepts are never simply acquired and then applied, rather they are slowly, progressively differentiated (I will elaborate upon concept acquisition in the section after next). There is no such thing as acquiring a concept in a final fashion because there is no such thing as a finalistic concept. Understanding these limitations, the facets of a concept (see previous section), and the conic model of a concept can serve as powerful heuristics for the educator.

Limitations of the Conic Representation - A Critique

Put in a most blatant way, the conic representation of a concept described in the previous section is simply wrong. The circumscribed circle which denotes the extension of a concept gives the impression that there is a clear cut border which differentiates members of the extension from non-members. However, in most cases we cannot so clearly distinguish members of a category from non-members. There seems to be a fuzzy border which is to a large extent dependent upon context and the pragmatics of the usage of language. Thus a chair in one context may be a table in another and vice versa. We could still theoretically salvage the model somewhat by using the center of the circle which denotes the extension as the most prototypical example of the category--that which contains the most relevant attributes. Then as we move away from the center we would encounter by gradation less typical examples to the fuzzy circumference containing the borderline cases--which are

those that could under certain circumstances be considered as members of the extension and in other circumstances would be excluded. A more appropriate depiction of the conic model appears in figure 4.

Place figure 4 approximately here

Even with this modification the model is imprecise. The problem that we have is that the border becomes so fuzzy that it loses meaning in terms of circumscribing a category. Take for example the following case:

A giant walks into New York City and sits to rest on the United Nations Building. Is the building a chair? In this context the answer is yes. Nevertheless we would never include the UN building within the extension of a "chair" and if we did then an infinite number of other entities could also appear in the extension by virtue of their ability to serve in the function of a chair.

What we begin to recognize is that the category or extension cannot be taken as a precise entity, and that a group of objects or events cannot denote the meaning of a concept. Rather the meaning of a concept derives from the relationships that exist amongst concepts. Furthermore, concepts do not exist as independent entities in a vacuum, rather they are dependent upon a whole framework of other concepts which infuse them with meaning--they are context dependent.

The same criticism of the extension given above can be extended to the intension. We can rarely, if ever, provide a precise definition that would capture the essence of a concept. There is no precise rule for categorizing members of a class that is not artifically based on several attributes and therefore excludes members who are unique. We

can only recognize a chair by the function it serves, and our definition is a relational one which relates the concepts to other concepts. A concept, therefore, is the common meeting place of inumerable attributes within a specific context. This captures Wittgenstein's (1953) concept of a "concept" which is pragmatically oriented and can be recognized as different things within different contexts or word games.* Wittgenstein's analogy of family resemblences to illustrate the continuity of a concept from one context to another is quite appropriate.

In summary, the conic model of a concept is inadequate. We find ourselves opting for a sematic network representation in which concepts derive their meaning from their relationship to other concepts (see figure 1). However, the conic model can still, if the limitations are clearly understood, act as heuristic tool for the educator.

Types of Learning Derived from the Conic Model

Two extreme paradigms of concept learning emerge from the conic model. These two types of learning are shown in figure 5.

Place figure 5 approximately here

Ausubel (1968), for example, distinguishes concept formation, which takes the form of bottom up induction, from later conceptual differentiation proceeding top down from vague to more clear conceptions, and bottom up only insofar as examples are used to clarify these vague concepts. The only case of "pure" bottom up learning is when two

*Wittgenstein speaks of words. I have shown that words and concepts are different. Yet his analysis is in fact relevant to concepts.

relatively independent concepts are integrated through a higher order concept in the process of superordinate subsumption. This is a highly creative leap when accomplished independently and dubbed by Ausubel as intergrative reconciliation. The classic example is Einstein's linking of "mass" and "energy" through his now famous $E = Mc^2$. However, most meaningful learning is in the form of subordinate subsumption where new information is subsumed into cognitive structure under existing concepts, and thus modifies existing cognitive structure by further differentiating existing concepts.

The modes of "bottom up" and "top down" learning form the basis of highly influential theories. Robert Gagné's (1970; Gagné and Briggs 1974) theory is clearly a "bottom up" theory. We start out at the lowest level on the hierarchy of prerequisites and work our way up to the terminal tasks. Curriculum Development turns out to be a task analysis, and instructional planning then follows the reconstruction of the terminal task through accomplishing the prerequisites derived from the task analysis. It turns out however, that save for very structured skills this approach is useless. Take for example a complex concept such as "evolution," how would one perform a task analysis? In such cases--which constitute the bulk of school learning--we need to be involved in conceptual analysis and it is senseless to go about teaching in a bottom up fashion. Rather, the most abstract and powerful concept must be presented first and then progressively differentiated by drawing upon examples.

The "top down" mode is adumbrated in Jerome Bruner's (1960) spiral curriculum. A single concept is not analyzed into its prerequisites

but rather a total discipline is analyzed so as to discern its structure and major concepts. These unifying concepts are presented time and again at different levels of sophistication. Thus a concept such as "energy" can be presented in a very intuitive fashion to preschoolers and elementary school children, then at a more sophisticated level in the junior and senior high, and finally with the use of calculus at the college level. I find this approach far more acceptable than Gagné's. Nevertheless it has the drawback of considering principles as immutable, rather than as conceptual frameworks that evolve over time.

The model of concept acquisition that we propose draws upon both of the above extremes but is substantially different from either. The teacher who keeps in mind the model while recognizing its adequacies will have a powerful heuristic for comprehending concept learning.

The acquisition of concepts

Concepts are never acquired! If our original concept as portrayed by the conic model were correct then it would be possible to acquire concepts. In that original model concepts had a clear definition (intension) and a clear cut class of members (extension). However, in our analysis we saw that no clear cut concepts exist except when artificially stipulated or operationally defined. This was true even for a concept as concrete as "chair" and ever more so for abstract concepts such as "democracy," "meaning," and "evolution."

Let us take the example of "energy." A first grader may have a vague concept of energy which may be riddled with misconceptions. A junior high student may have, and usually does, a more sophisticated concept of energy with far less misconceptions. However, an undergraduate majoring in the physical sicences would have an even more

sophisticated concept of "energy." His professor or a graduate student in physics would have an even more elaborate concept of "energy." But even the professor is surpassed by scientists specializing in this domain. The truth is, therefore, that nobody has a concept in any finalistic form, rather, each has the concept differentiated to some extent.

The above is true also for more concrete concepts. Although I have a concept of a "chair" similar enough to yours to enable communication, our concept of chair is far less differentiated than that of an antique dealer. The same object that I may recognize as an example of the concept "chair" the antique dealer may recognize as being made of a now extinct type of mahogany and of design characteristic of the 16th century and thus worth a lot of money.

The point I am making is quite simple and straight forward. Concepts are never learned on an "all or none" basis, rather they are progressively differentiated. This situation affords continual refinement of our existing conceptions. Furthermore, because of this flexibility concepts can continue to evolve within disciplines enabling further progress. If the conic model were precise or if concepts were learned on an "all or none" basis there would remain no flexibility for change. This point deserves further elaboration, but this is beyond the scope of this paper.

Theories that view learning as an inductive bottom up process are incorrect according to our analysis. Such theories postulate that prerequisite concepts are first acquired before the student can move on to higher order concepts. Their view, therefore, is the simplistic view that the student one moment has no concept and that later the prerequisite

concept is acquired in a finalistic fashion. Then the student combines these prerequisite concepts to acquire a higher order concept in a finalistic fashion and so on up the hierarchy. Previously we showed that the analysis of a concept into prerequisities is no simple matter and thus no simple analysis a la Gagné can accomplish this. Now we add the fact that the type of learning that such a theory postulates is also untenable.

The process of meaningful learning is therefore a process whereby new information is related to existing knowledge in cognitive structure. This is a process of progressive differentiation of concepts. A vague concept riddled with misconceptions can either become more scientifically accurate and thus afford greater cognitive power in terms of discrimination and problem solving, or can inhibit meaningful learning by becoming a more engrained and differentiated misconception. The process of meaningful learning is an active process best captured by Ausubel's (1968) concept of subsumption. An analysis of Ausubel's theory of learning is clearly beyond the scope of this paper. However a brief discussion of two major types of subsumption will be briefly mentioned.

In subordinate subsumption new information (concepts and propositions) are related to a subsuming concept in cognitive structure which is at a higher level of generality. This is the most common form of learning. For example, using figure 1 as an illustration, the student may subsume the concepts of "epistemic" and "procedural knowledge" under the more abstract existing subsumer "knowledge." This is not a passive process of absorbing information, not a sponge soaking up liquid. For in the process of meaningful learning the subsuming and the subsumed concepts

are somewhat modified. Subsumption is not a simple class inclusion either, rather new conceptual linkages are established which modify and differentiate the existing concept. Therefore, the student's understanding of the concept of "knowledge" is modified subsequent to subsuming the subordinate concepts and propositions. This is captured in the following formulation of meaningful learning:

$$A + a_1 \longrightarrow A'a_1' + a_2 \longrightarrow A''a_1'' a_2' \ldots$$

Where A is the subsuming concept (knowledge) and a_1, a_2 are subsumed concepts (epistemic and procedural).

The process of superordinate subsumption happens more rarely especially when this is achieved independently. In such a case two or more previously unrelated concepts are integrated. Again this is an active process in which the integrated concepts change the meaning that they had before becoming related. Thus if we again refer to figure 1 for purposes of illustration "intellectual skills" and "concepts" may become related through acquiring the concepts of "epistemic knowledge." This process can be summarized in the following formulation:

$$A, B + C \longrightarrow C, A, B,$$

Obviously there are many more types of subsumption, especially subordinate subsumption, but this brief exposition must suffice for the rest of our discussion.

Curriculum Development and Instruction Planning--Preparing to Teach Meaningfully

Most concepts that are acquired spontaneously are riddled with misconceptions. As we have seen these misconceptions can be progressively differentiated so as to become more engrained and thus in the

long run inhibit meaningful learning; or, they can be ameliorated enabling further rapid and fruitful meaningful learning. The teacher, if appropriately prepared, can accomplish the task of facilitating meaningful learning.

The teacher needs at least two prerequisite bodies of knowledge in order to be successful. These may be dubbed the necessary but not sufficient conditions for meaningful learning:

1) An expertise in the subject-matter domain that the teacher purports to teach is a sine qua non. The teachers need a profound conceptual grasp of the subject-matter so that they can assess students' misconceptions and redirect their thinking. Furthermore the teacher needs a methodological grasp of the discipline so that the origin of knowledge claims can be explained.

2) The teacher must understand the process of meaningful learning. Without such a grasp there is the danger that rote learning will be promoted. Much of curriculum development, instructional planning and the evaluation of learning outcomes can only be adequately achieved with a clear grasp of learning theory. A theory of learning is the basis for a theory of instruction and not vice versa.

In essence we are making a demand that teachers be both epistemologists and psychologists. This may be difficult to ask for. Yet it is the bare minimum necessary for meaningful teaching.

Figure 6 summarizes the roles of epistemology and psychology in curriculum development and instructional planning, utilizing the concept of "concept" provided earlier in this paper. On the left side we find the subject matter or the epistemology, on the right side we find the learner, or the psychology.

Place figure 6 approximately here

The first task that a teacher is faced with is the analysis of the content to be taught. The teacher must "unpack" the knowledge to be taught (Gowin, 1976). The "unpacking" includes the construction of concept maps and the analysis of knowledge claims. A more detailed outline of the process is beyond the scope of this paper.

The second task that is essential is the evaluation of the students' existing relevant prior knowledge. This should result in a hypothetical "cognitive map" which reveals existing relevant conceptual connections in the students' cognitive structures as well as existing misconceptions. The way in which one evaluates what students know is one of the fundamental problems of educational psychology. Again, a detailed analysis of this problem is beyond the scope of this paper. Our ideas concerning the use of clinical interviews for the evaluation of cognitive structure are discussed elsewhere (Pines et al. 1978; Pines 1979, 1980).

The curriculum is in essence the discrepancy between what the student knows and what needs to be known. This includes the amelioration of existing misconceptions. Each of the concepts that is to be introduced and differentiated is displayed by the conic model with the fuzzy borders. Conceptual intensions can be introduced by the use of

advance organizers and further differentiated using concrete props, examples, and the actual methodology used in deriving propositional relationships. The available examples for explaining the concepts are included in the extension. The choice of the instrumental content (Johnson 1977) to be used from the extension is based upon what is familiar to the student.

Thus we see that a teacher, in order to be successful, needs extensive preparation. The conic model provides a heuristic prescription for both "top down" and "bottom up " instruction.

Conclusion

Teaching effectively is an awesome task and demands highly qualified professionals. One of the major tasks with which teachers are concerned is providing students with conceptual frameworks to facilitate their thinking and problem solving activities. Toward this end teachers need a fine grasp of the conceptual structure of the subject matter that they purport to teach and an understanding of the process of meaningful learning.

Because concepts are the basis for human thought and understanding, a significant portion of this paper was devoted to the analysis of the concept of a "concept." A model was proposed and criticized. This model was used to distinguish two types of learning--inductive, "bottom up" and deductive, "top down"--then later used as a heuristic within a model of curriculum and instruction.

The latter portion of the paper was devoted to the types of expertise that are considered necessary conditions for facilitating meaningful learning. The paper culminates in a simplified model of curriculum and instruction that presupposes the teacher's expertise

in the domains of epistemology (especially as related to their subject-matter domain) and psychology.

Thus, I have attempted in this paper to describe concepts and their acquisition. Because of the scope of the paper almost all of the issues discussed are treated superficially: Both the epistemology and the psychology are mentioned with examples, but never treated sufficiently. A more extensive treatment of each topic--epistemology, psychology, and curriculum--although definately warranted, necessitate at a book length expositions. These will be forthcoming.

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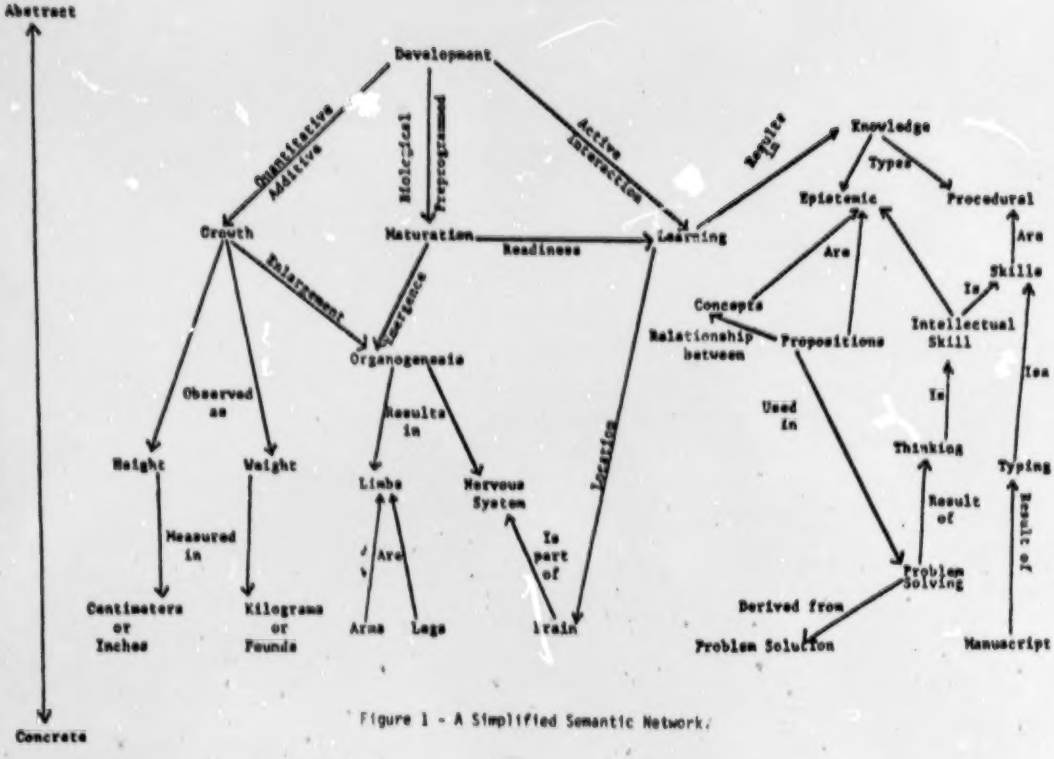

Figure 1 - A Simplified Semantic Network.

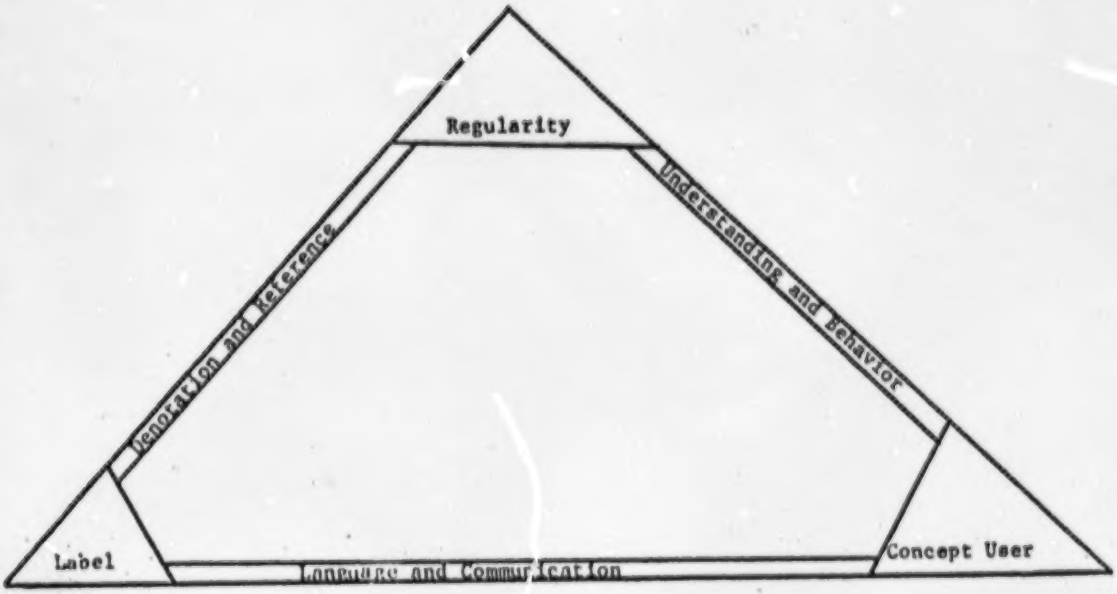

Figure 2 - The Trifaceted Concept of "Concept".

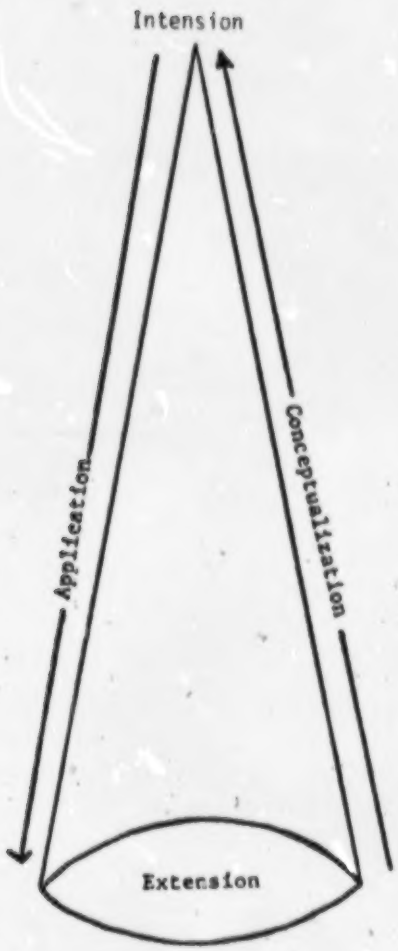

Figure 3 - The Conic Model Representation of the Concept of a "Concept,"

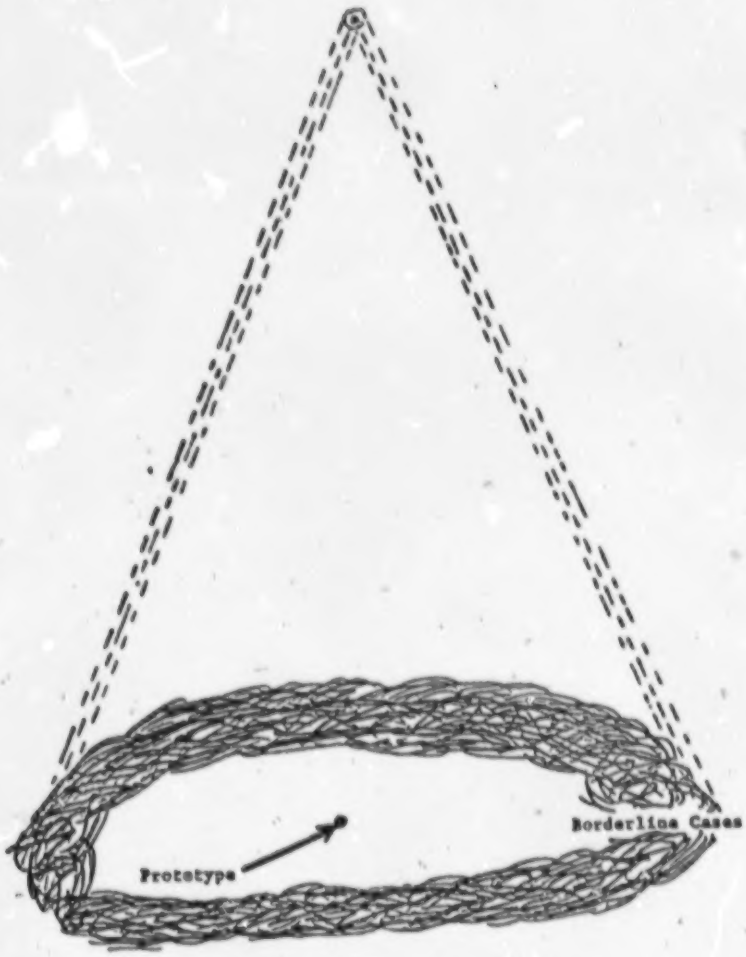

Figure 4 - A Modified Version of the Conic Representation of a Concept Taking Into Account the Fuzzy Border of the Extension.

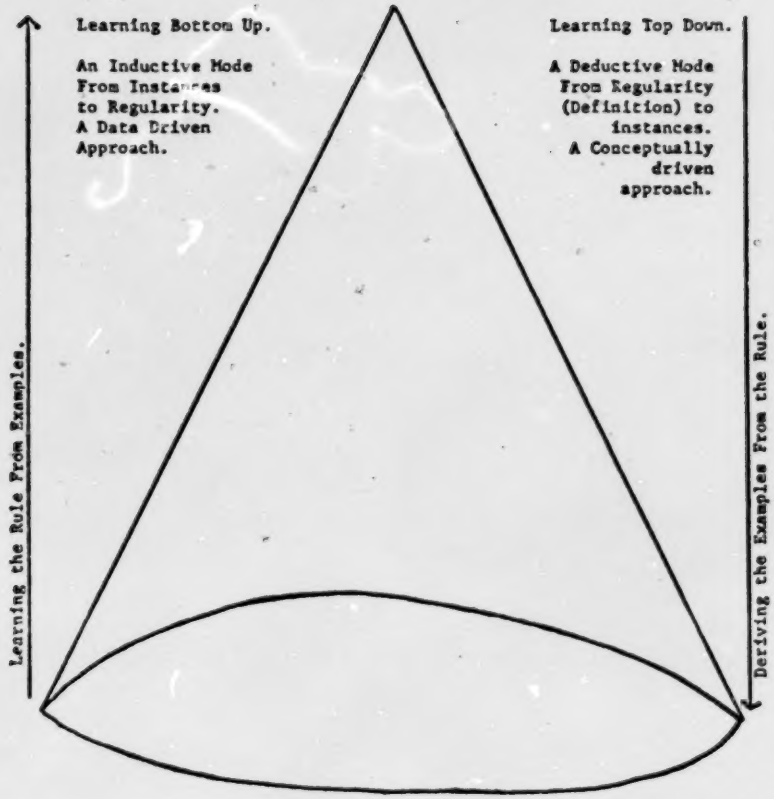
Learning Bottom Up.
An Inductive Mode From Instances to Regularity. A Data Driven Approach.
Learning Top Down.
A Deductive Mode From Regularity (Definition) to instances. A Conceptually driven approach.
Learning the Rule From Examples.
Deriving the Examples From the Rule.

Figure 5 - Two Paradigms of Concept Learning as Derived From the Conic Model.

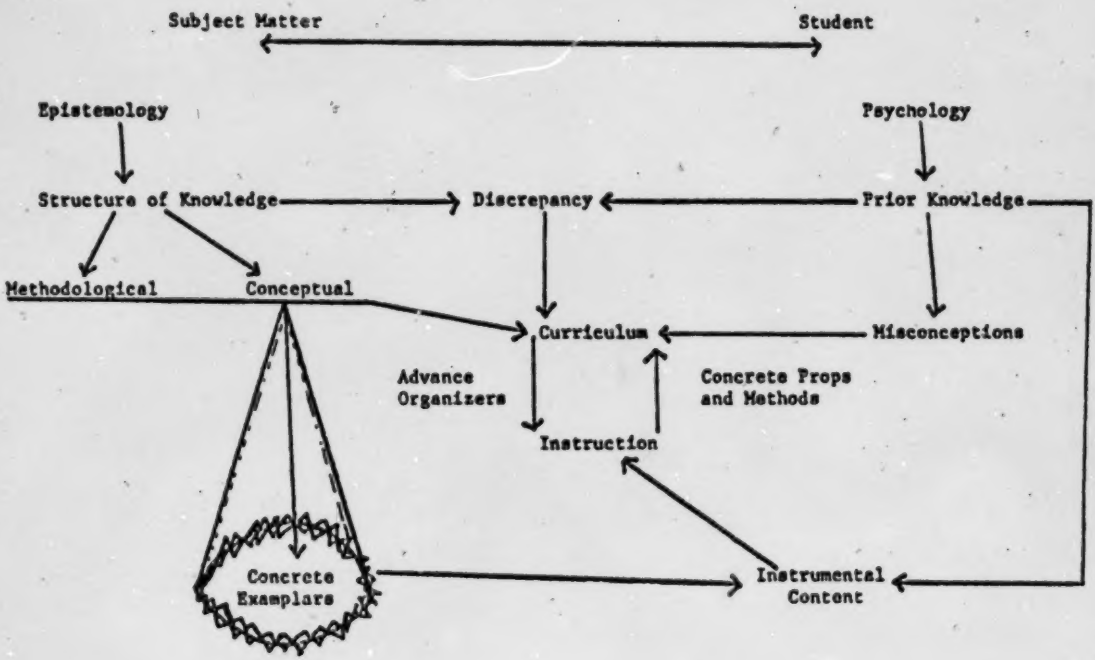

Figure 6 - Proposed Model for Directing Curriculum Development and Instructional Planning.